Parker OIL-X Coalescing Filters

A White Paper By Mark White - Compressed Air Treatment Product & Applications Specialist

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Compressed Air Contamination

For over 100 years, compressed air has been recognised as a safe and reliable power source that is widely used throughout industry. Known as the 4th utility, approximately 90% of all manufacturing companies use compressed air in some aspect of their operations. Unlike gas, water & electricity which is supplied to site by a utility supplier and to strict tolerances and quality specifications, compressed air is generated on-site by the user. The quality of the compressed air and the cost of producing this powerful utility is therefore the responsibility of the user.

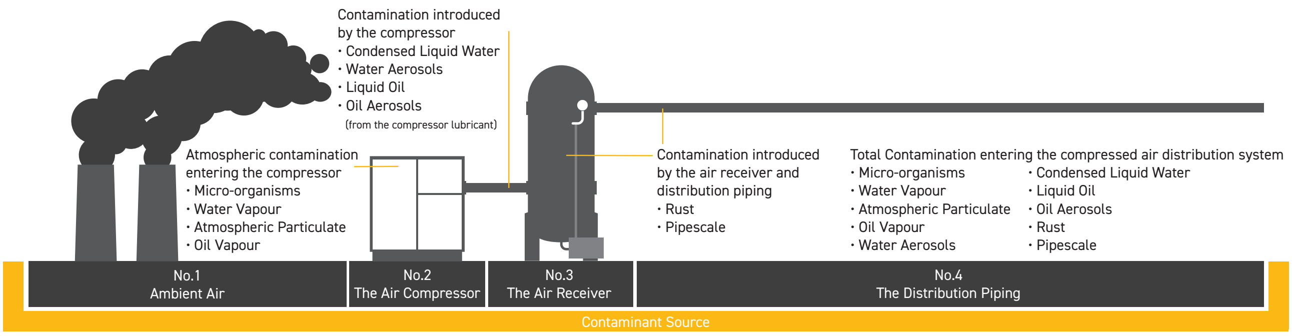
The Problem with compressed air.

Compressed air systems inherently suffer from performance and reliability issues and almost all of the problems associated with the compressed air system and many manufacturing related quality issues can be directly attributed to contamination found in the compressed air.

A standard compressed air system contains a large array of both visible and invisible contamination which actually originate from four different sources

10 CONTAMINANTS

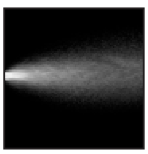
FOUR SOURCES



Water	Oil	Particulates	Organic
Water Vapour	Oil Vapour	Atmospheric Particles	
Liquid Water	Liquid Oil	Compressor Wear Particles	Micro-organisms
Water Aerosols	Oil Aerosols	Rust / Pipescale	

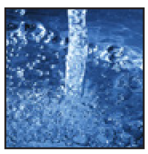

Rust & Pipescale


Micro-organisms


Water Aerosol
Oil Aerosol


Liquid Oil

Particulates


Liquid Water


Water Vapour


Oil Vapour

Contaminant Reduction

To operate any compressed air system, safely and cost effectively, contamination must be reduced to acceptable limits. The importance of reducing contamination is increased when compressed air is used as part of a manufacturing process.

Coalescing filters

When considering purification equipment, coalescing filters are vital for the cost effective operation of any compressed air system, regardless of the type of compressor installed. They can be considered the most important piece of purification equipment as they not only treat 6 of the 10 main contaminants found in compressed air, they also protect the compressed air dryer and adsorption filters which form part of the purification system.

Purification Technologies	Contaminants									
	Atmospheric Particles	Rust	Pipescale	Micro-organisms	Liquid Water	Water Aerosol	Water Vapour	Liquid Oil	Oil Aerosol	Oil Vapour
Water Separator					•			•		
Coalescing Filters	•	•	•	•		•			•	
Adsorption Filter										•
Dryer							•			
Dry Particulate Filter	•	•	•	•						
Sterile Filters				•						

OIL·X®

The first coalescing filter

The origins of modern compressed air filtration can be traced back to domnick hunter in 1963, it was the first company to use microfibre filter media for purification applications, changing the compressed air industry forever. The OIL-X filter range introduced in 1972 was the first filter range to fully utilise this ground breaking technology and has always been synonymous with high quality compressed air.

Now in the 21st century, the OIL-X name remains, but the technology has evolved.

Original OIL-X

OIL-Xplus

OIL-X EVOLUTION

OIL-X

So how do coalescing filters work?

The purpose of this white paper is to explain the operation of coalescing filters, how they are tested, how coalescing filters consume energy and how the filtration performance and energy consumption of different co-alescing filters available on the market differ from each other.

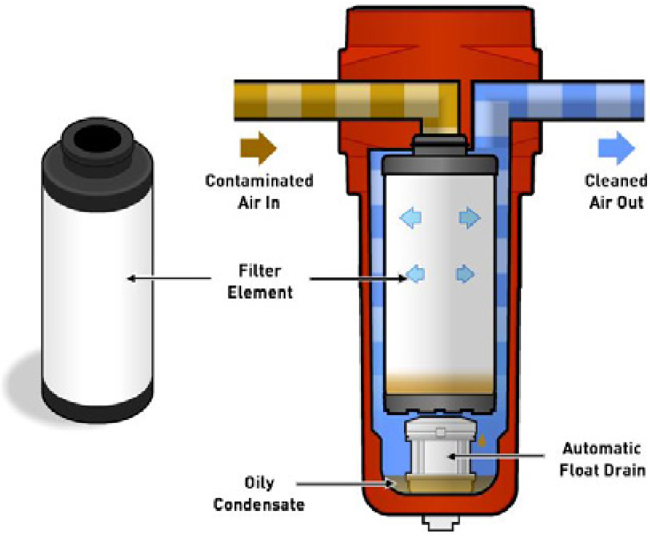
Coalescing Filters Basic Principles of Operation

Coalescing filters rely on what is known as mechanical filtration for their effectiveness.

At the heart of any coalescing filter is the filter element. Coalescing filter elements have 3 main phases of operation:

- **Phase 1 - Aerosol & Particulate Capture**
- **Phase 2 - Coalescing**
- **Phase 3 - Anti-Re-entrainment**

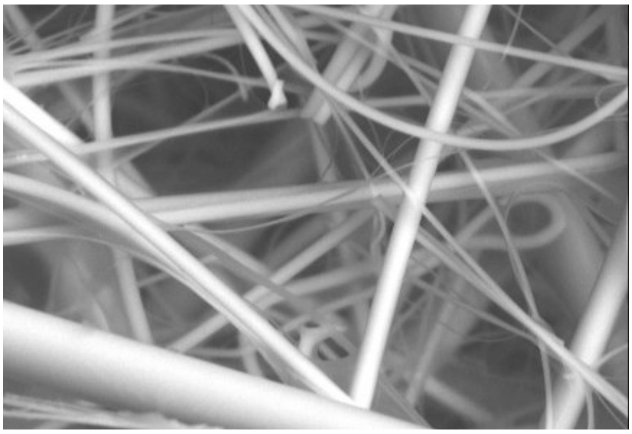
Coalescing filter elements utilise a deep bed of fibrous filter media. The filter media itself is typically supplied in sheet form or on rolls. As supplied, the filtration bed depth is not enough to provide adequate filtration, so the media is then constructed into a filter element and it is the construction method used that provides the deep bed of filter media.



A scanning electron microscope (SEM) image shows what filter media looks like when magnified.

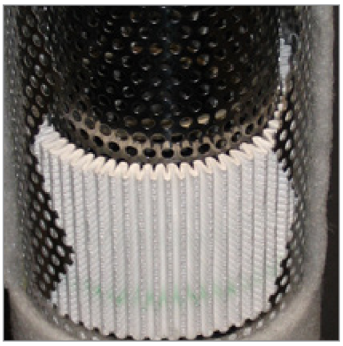
The space between the fibres is known as the voids volume. A large voids volume provides:

- **Higher dirt holding capacity**
- **Lower resistance to air flow (low pressure loss)**
- **Lower running costs for the system**

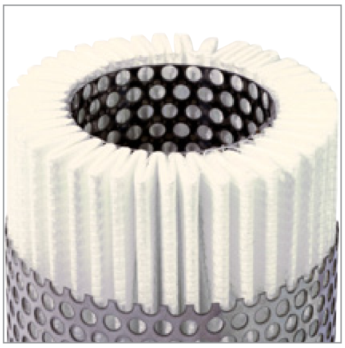


Although they are often visually similar, the filtration media used and the method to construct the media into a filter element will differ between manufacturers. The performance of a filter element cannot be determined simply by looking at it and two elements that look identical can have vastly differing filtration performance, energy consumption and lifetime.

Wrapped Construction



Standard Pleated Construction



Deep Pleated Construction

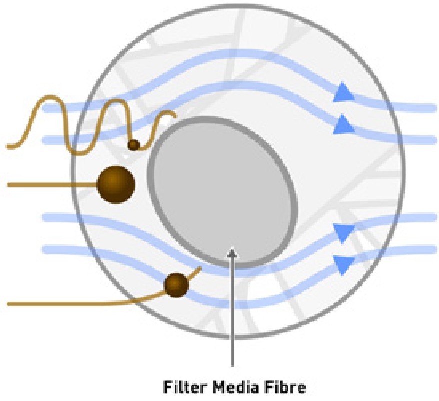
Coalescing Filter Operation Phase 1

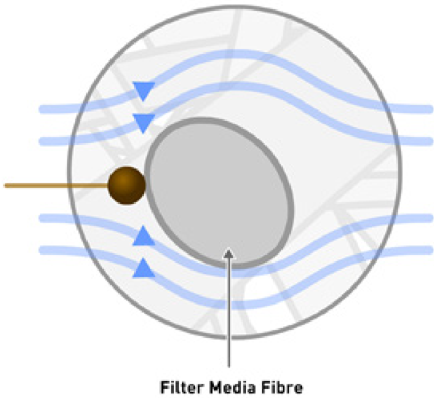
Aerosol & Particulate Capture

As compressed air flows through a filter element, liquid aerosols and particulate are collected on the individual media fibres by means of three capture mechanisms:

- **Direct Interception**
- **Inertial Impaction**
- **Diffusion**

Each mechanism captures aerosols and particles of different sizes.





Capture Mechanism - Direct Interception

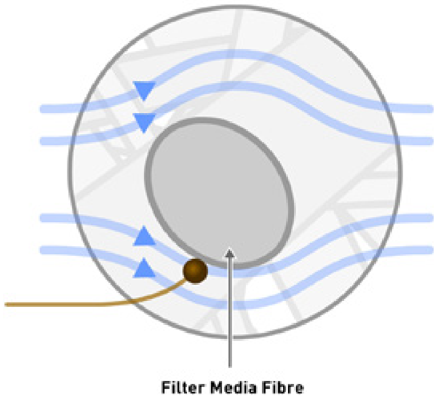
Particle Size > 1 micron

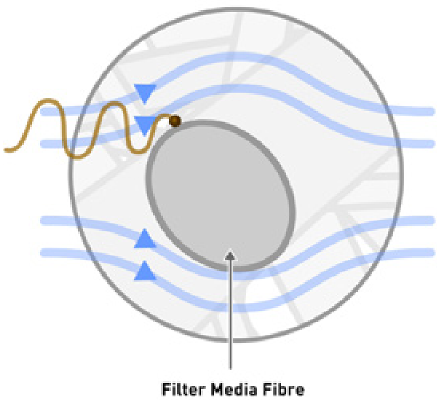
Direct Interception occurs when the entrained aerosols or particulate in the compressed air is unable to find a direct path through the deep bed of filter media. It contacts with the surface of the filter media strand where it is collected and retained.

Capture Mechanism - Inertial Impaction

Particle Sizes 0.3 - 1 micron

Due to the randomness of the glass fibre bed, the compressed air must follow a tortuous path. As the air stream rapidly changes direction to avoid the strands of filter media fibres, aerosols and particulates of sufficient mass are unable to do so due to their inertia, these too collide with the filter media strand and are collected and retained.





Capture Mechanism - Diffusion (Brownian Motion)

Particle Size < 0.3 micron

Very small aerosols and particulate have very low mass and behave as if they were molecules of gas. They travel within the compressed air stream in a random pattern known as 'Brownian Motion'. As with a gas, collisions of these aerosols and particulates with themselves and the nanofibre glass fibres are common and thus they are also collected and held.

Filter Efficiency & Most Penetrating Particle Size

It is important to understand that depth filters such as coalescing and dry particulate filters are not absolute rated, i.e. they do not capture and retain 100% of contamination entering the filter.

Instead, depth filter technical data will typically show a "Filtration Efficiency" rating alongside the filter's particle and oil aerosol reduction capability.

The efficiency rating of a depth filter (usually stated as a percentage) denotes how much of the aerosols and particulates entering the filter element are captured by the filter media.

Filtration Grade	Filter Type	Particle Reduction (inc water & oil aerosols)	Max Remaining Oil Content at 21°C (70°F)	Filtration Efficiency
AO	Coalescing	Down to 1 micron	0.5 mg/m^3 0.5 ppm(w)	99.925%
AA	Coalescing	Down to 0.01 micron	0.01 mg/m^3 0.01 ppm(w)	99.9999%

Why does a depth filter not capture and retain 100% of the contamination?

As compressed air contains particles of different sizes, all 3 capture mechanisms (Direct Interception, Inertial Impaction and Diffusion) will be called upon.

Each capture mechanism has a collection efficiency which is directly related to the particle size being removed and these overlap one another, for example as Inertial Impaction collection efficiency reduces (as particle sizes reduce), the collection of particles by Diffusion increases.

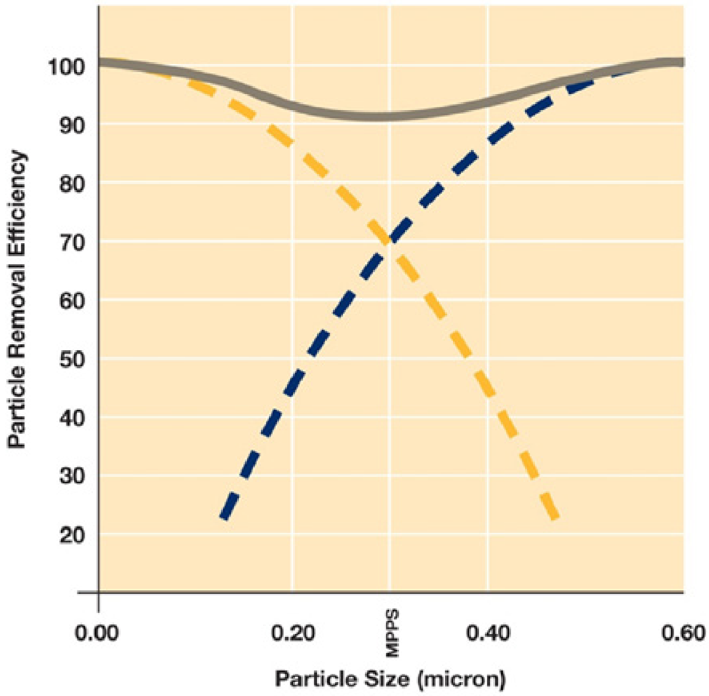
When the capture mechanisms are combined together, a particle size which is most likely to penetrate the filter, known as the Most Penetrating Particle Size (MPPS), can be determined.

For particle sizes that are smaller or larger than the MPPS, the particle removal efficiency increases towards 100%.

Example: if a filter has an efficiency of 99.9999% at an MPPS of 0.3 micron, then 0.0001% of what goes into the filter at that size comes out of the other side and enters the compressed air system.

The particle removal efficiency and the particle size at which the MPPS exists is dependent upon the filter media, element construction and the velocity of the gas and will vary for different filter manufacturers.

Example of a Filter Particle Removal Efficiency Graph



Efficiency will vary between different filtration medias and different filter manufacturers.

The test method ASTM D (2986-95) is commonly used to test filtration efficiency (DOP Test).

ASTM D (2986-95) has an accuracy to 4 decimal places.

Coalescing Filter Operation Phase 2

Coalescing

Once collected, the aerosols on the fibres become targets for the remaining airborne aerosols, causing them to grow over time. When they have grown large enough, the air flowing across the collected aerosols forces the liquid to move. The mobilised liquid collects additional liquid as it moves along the fibres.

As the liquid volume increases, it is no longer restricted to moving along the fibres and becomes a moving film of liquid. This film of liquid travels through the media until it reaches the outer surface of the filter element.

Coalescing Filter Operation Phase 3

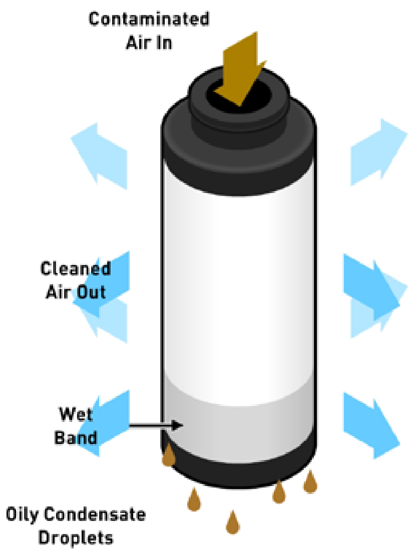
Anti Re-entrainment

A system of anti-re-entrainment is fitted to the filter element and is provided by way of a porous foam or fibrous drainage layer. The drainage layer prevents the bulk liquids from getting back into (re-entraining) into the air stream.

Due to gravity, liquids move down through the drainage layer towards the base of the element.

Once the liquid reaches the base of the filter it forms a 'wet band'. This wet band is placed in a region of relatively low turbulence and air flow to reduce the risk of re-entrainment.

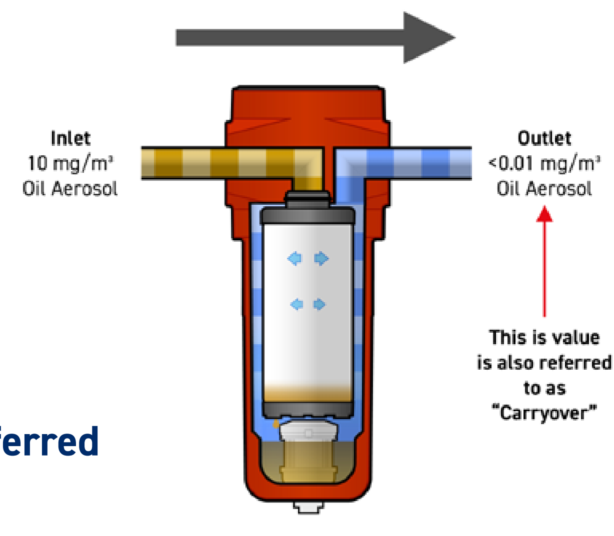
Drained oil can then discharge from the compressed air by means of an automatically activated drain valve for disposal in a safe and responsible manner.



Carryover

Technical data for coalescing filters will typically include a "Maximum Remaining Oil Content" figure at a reference temperature.

This figure is based upon a challenge amount of oil aerosol entering the filter and a measurement of how much oil aerosol is remaining in the compressed air after the filter. It is a measured figure and shows the effectiveness of all 3 capture mechanisms.



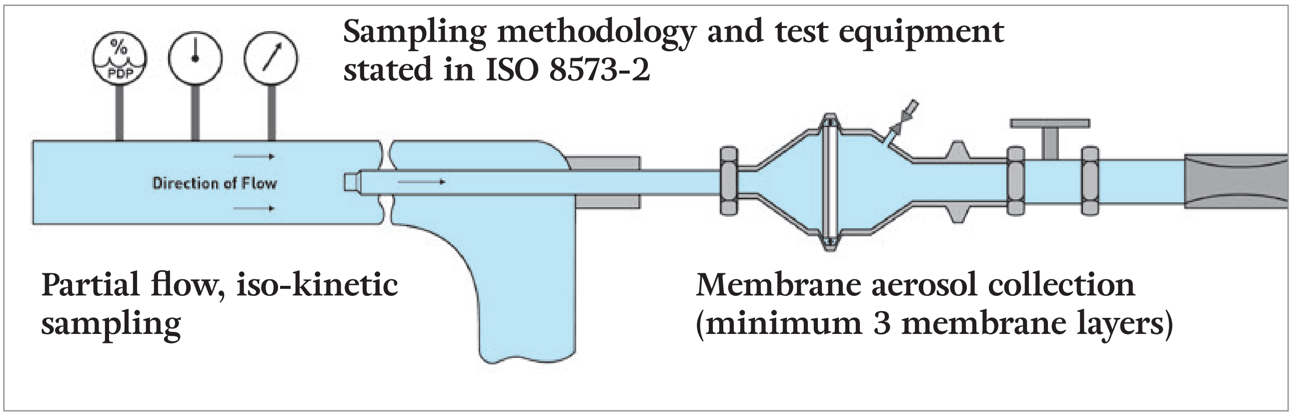
In filtration terms, this value is often referred to as "Carryover" or "Oil Carryover"

How Coalescing Filter Performance is Tested

When coalescing filters were first developed, a method of testing for oil aerosol in compressed air was required to show their performance. The early test method first developed by domnick hunter, later became a PNEUROP* standard and was eventually adopted as an ISO standard in the form of ISO 8573-2.

*PNEUROP the European association of manufacturers of compressors, pneumatic tools and air treatment equipment.

ISO 8573-2 identifies the test methodology and test equipment to accurately test for aerosols in a compressed air system. However when ISO 8573-2 is used to test filter performance there is a problem.



To test a coalescing filter's performance to see how it will perform in a compressed air system requires oil aerosols to be generated and introduced at the inlet of the filter. The value of oil aerosol used is known as the "inlet challenge concentration".

In the past, each filter manufacturer would use a different inlet challenge concentration to test and rate their products.

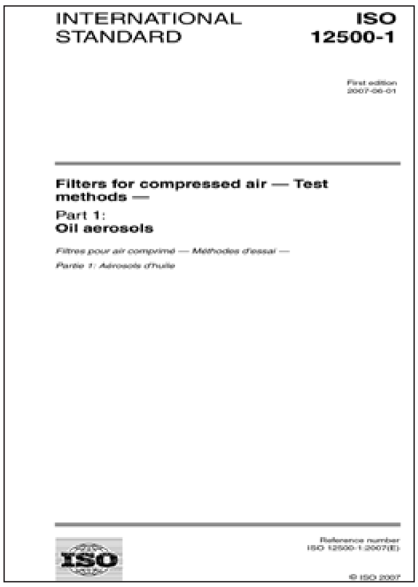
To a user performing a comparison with product literature, product performance and energy consumption would look comparable, whilst the actual filtration performance between filters (and energy consumption) could vary, often quite significantly.

Introducing ISO 12500-1 - Coalescing Filter Testing Standard

To allow for the accurate testing of coalescing filters and provide a standardised method for displaying performance data, ISO 12500-1 was developed.

Testing in accordance with ISO 12500-1 challenges each filter with a specific inlet concentration of oil aerosol, on standardised test equipment and at a standardised set of operating conditions.

Comparing filters that have been tested in accordance with the ISO 12500-1 standard, the user should be able to make a more informed purchasing decision as the filters have been tested at the same reference conditions and identical inlet challenge concentrations.


INTERNATIONAL STANDARD

ISO 12500-1

First edition 2007-06-01

Filters for compressed air — Test methods —

Part 1:
Oil aerosols

Filtres pour air comprimé — Méthodes d'essai —
Partie 1: Aérosols d'huile

Reference number ISO 12500-1:2007(E)

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Testing a Filter in Accordance with ISO 12500-1

ISO 12500-1 states the oil aerosol content of the compressed air downstream of the filter is measured using the proven sampling methodology and test equipment stated in ISO 8573-2.

In addition to this, ISO 12500-1 introduces an aerosol generator, placed upstream of the filter to provide an aerosol challenge.

The aerosol generated will have an average size of 0.3 micron (a typical MPPS of filtration media).

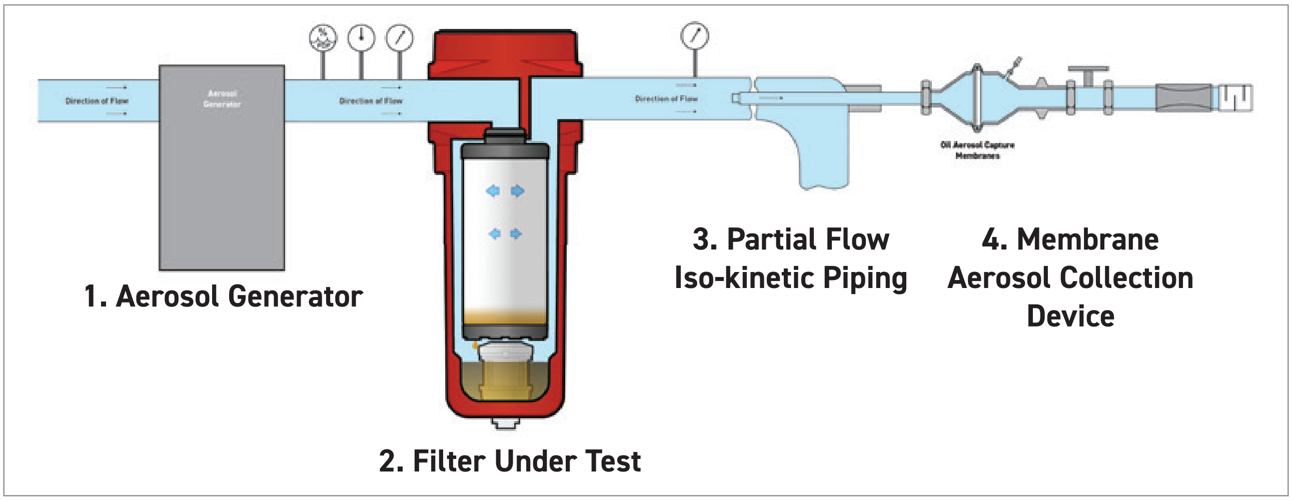
Two oil aerosol inlet concentrations are stated in the standard, these are 40mg/m^3 & 10mg/m^3.

The challenge concentration selected is determined by the filter manufacturer and the value must be stated when showing product performance data.

To provide accurate test results, ISO 12500-1 requires the testing is repeated 3 times on the same filter element and the results averaged.

At least 3 examples of each filter model must also be tested. Therefore, the performance shown for an individual filter is the average of 9 separate tests.

The diagram below shows an ISO 12500-1 sampling rig.



The ISO 12500-1 sampling rig consists of:

1. The Aerosol Generator
2. The Filter Under Test
3. The ISO 8573-2 recommended partial flow iso-kinetic piping
    - This is used when the air flow of the filter is greater than the maximum air flow of the sampling equipment (in this case the membrane collection system)
    - Iso-kinetic sampling ensures that the air velocity and aerosol distribution in the membrane holder matches the velocity and aerosol distribution in the main piping
4. The ISO 8573-2 recommended membrane aerosol collection device
    - This device contains a minimum of 3 membranes that capture oil aerosols
    - The oil content is measured post sampling using a solvent extraction method
        - Solvent is passed over the membranes to remove the oil from the membrane
        - The solvent is then analysed using FTIR (Fourier-transform infrared spectroscopy) and an oil concentration determined

ISO 12500-1 Test Procedure

Three filters of the same size must be tested, and each filter must be tested three times.

1. Select an appropriate challenge concentration from the ISO 12500-1 standard
   - 40mg/m³ or 10mg/m³
2. Calculate challenge for filter
   - For example, if a filter has a maximum flow rate of 250m³/hr at 7 bar g and a challenge concentration of 40mg/m³ has been selected, then the filter will be challenged with a total of 250 m³/hr x 40 mg/m³ = 10,000mg/hr of oil aerosol
3. Flow the filter at 100% of its rated air flow & record the initial dry differential pressure
4. Set up the aerosol generator
5. Pre-condition filter / element under test with oil aerosol
   - Before full testing can commence, the filter must first be conditioned so that performance is recorded with the element in a saturated state (this simulates coalescing filter element performance in normal operation).
   - Conditioning requires the filter element to be challenged with the selected challenge concentration (40mg/m³ or 10 mg/m³) until equilibrium has been achieved
   - Pre-conditioning typically takes between 8 & 16 hours depending on the inlet challenge selected and filtration grade being tested
   - Pre-conditioning ensures the 'ready to test' criteria (equilibrium) stated in the ISO 12500-1 standard is met
6. Challenge filter at 100% of rated flow with selected inlet oil aerosol challenge
   - 3 samples to be taken using separate membrane sampling equipment for each
7. Record the saturated (Wet) differential pressure
8. Perform solvent extraction process on the membranes from each of the 3 samples individually
9. Using the FTIR, analyse each of the 3 solvent samples individually
10. Record the oil carryover (for each of the 3 samples)
11. Repeat steps 3 to 10 on two new filters
12. Calculate average oil carryover (from the 9 results)
13. Calculate the average saturated dP (from the 9 results)

Filtration Grade	Filter Type	ISO 12500-1 Inlet Challenge Concentration	Max Remaining Oil Content at 21°C	Initial Dry Differential Pressure	Initial Saturated Differential Pressure
AO	Coalescing	40 mg/m³	0.5 mg/m³	<70 mbar	<125 mbar
AA	Coalescing	10 mg/m³	0.01 mg/m³	<70 mbar	<125 mbar

ISO 12500-1 Results

The output from ISO 12500-1 testing allows a manufacturer to show their oil carryover performance plus their initial dry and initial saturated (wet) differential pressures (dP's).

Energy Consumption

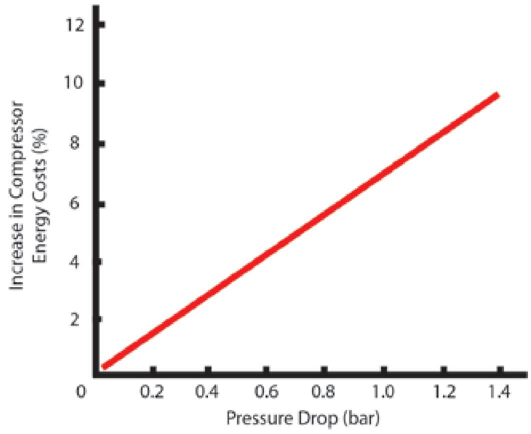
Energy consumption is a major factor for any manufacturing facility and each purification technology installed will consume energy, either directly or indirectly. Some purification technologies require direct connection to an electrical supply and their electrical requirements including power consumption are typically stated in literature.

However, all purification technologies also have an indirect impact on electrical consumption in the form of pressure loss (also referred to as pressure drop, differential pressure or simply shortened to dP).

Pressure Loss

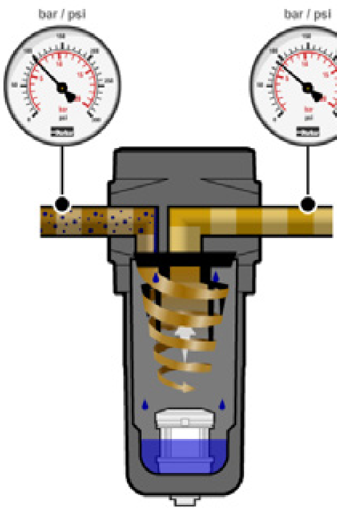
Any restriction to air flow reduces the pressure available at the point of use and therefore compressors are often found generating at a pressure above that required for the application, to cater for pressure losses in the compressed air system.

There is a cost associated with generating compressed air at higher pressure to overcome pressure losses in terms of energy consumed by the compressor. On average, it is found that for every 1 bar of additional generation pressure required to overcome pressure drop, there is an increase of approximately 7% in specific energy consumed by the compressor. **Therefore keeping pressure losses low helps reduce operating costs.**

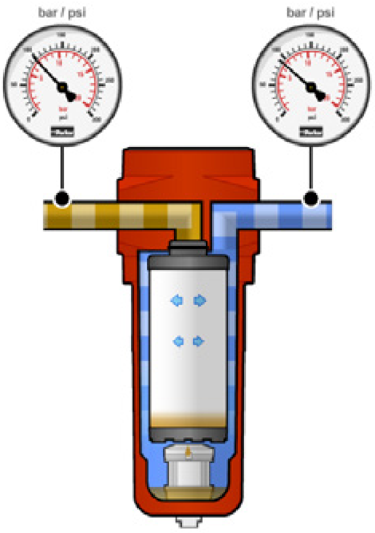


How Filters Consume Energy

With a compressed air water separator, pressure loss is classed as a fixed pressure loss where as with a coalescing filter or dry particulate filter, pressure losses are a combination of fixed pressure loss and incremental pressure loss.



Water Separators
Fixed Pressure Losses Only



Coalescing Filters
Fixed & Incremental Pressure Losses

Fixed pressure losses are designed into the separator / filter from the beginning and come from the water separator housing / filter housing and from the water separator module or filter element endcap designs.

Incremental pressure losses on the other hand come from the filter element as its starts operating (Saturation of the filter element on coalescing filters and particulate blockage on coalescing and dry particulate filters).

The Difference Between Wet & Dry dP

Pressure losses in compressed air purification equipment literature is stated as dP or differential pressure. To avoid confusion, coalescing filter literature should show both a dry differential pressure and a wet (saturated) differential pressure.

Filtration Grade	Filter Type	Initial Dry Differential Pressure	Initial Saturated Differential Pressure
AO	Coalescing & Dry Particulate	<70 mbar (1 psi)	<125 mbar (1.8 psi)
AA	Coalescing & Dry Particulate	<70 mbar (1 psi)	<125 mbar (1.8 psi)

For coalescing filters, the dry dP figure can largely be ignored.

This is due to the way coalescing filters "wet out" with oil and water aerosols in the first 24 hours of operation.

If the literature of a coalescing filter does not indicate the differential pressure as wet or saturated, then clarification should be sought from the manufacturer as the wet dP is the true starting dP of a coalescing filter.

Literature for dry particulate filters will only have a dry differential pressure as oil and water aerosols are not present.

Important Note: dP versus flow

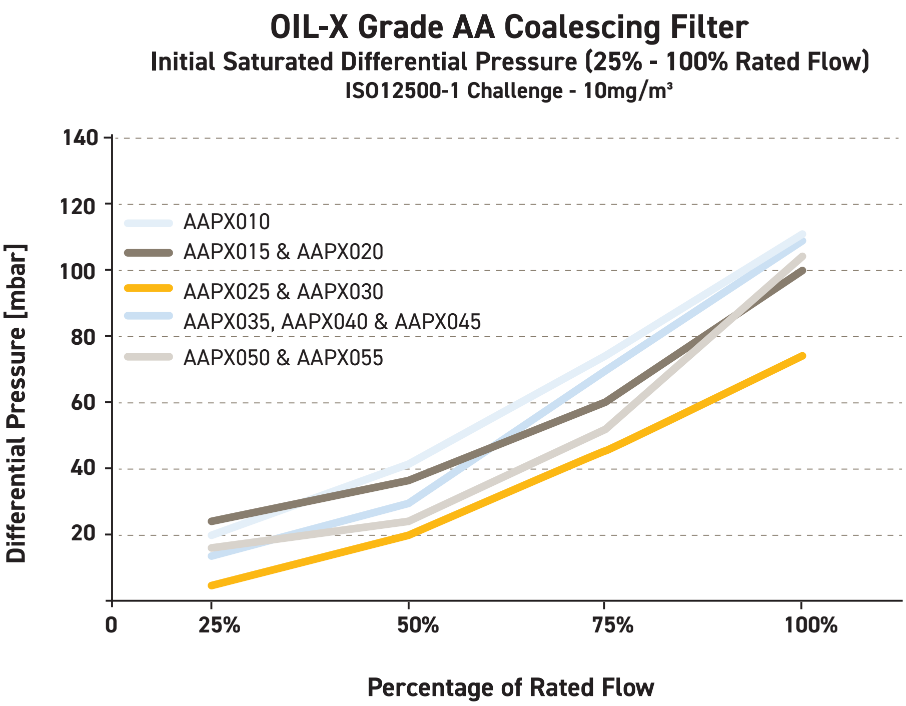
Typically, the differential pressure losses quoted for coalescing filters in accordance with ISO 12500-1 is based upon a filter that has been wetted out and tested / flowed at 100% of its rated capacity.

Generally, however, compressed air filters are not flowed at 100% capacity as when sizing a filter, one is picked with a flow rate equal to or greater than the flow of the compressed air system (at minimum operating pressure).

Therefore, as the filter is typically not operating at 100% capacity, the dP of the filter will start at a lower point than the quoted figure.

Parker OIL-X filters are the first range of industrial compressed air filters to show differential pressure not only at 100% of rated flow, but also at 25%, 50% and 75% of rated flow and for each filter model.

This provides a more realistic view of initial dP.



Wet dP Is Just the Beginning

It is also important to understand that the dP data shown in product literature is indicative of a filter in an “as new” condition.

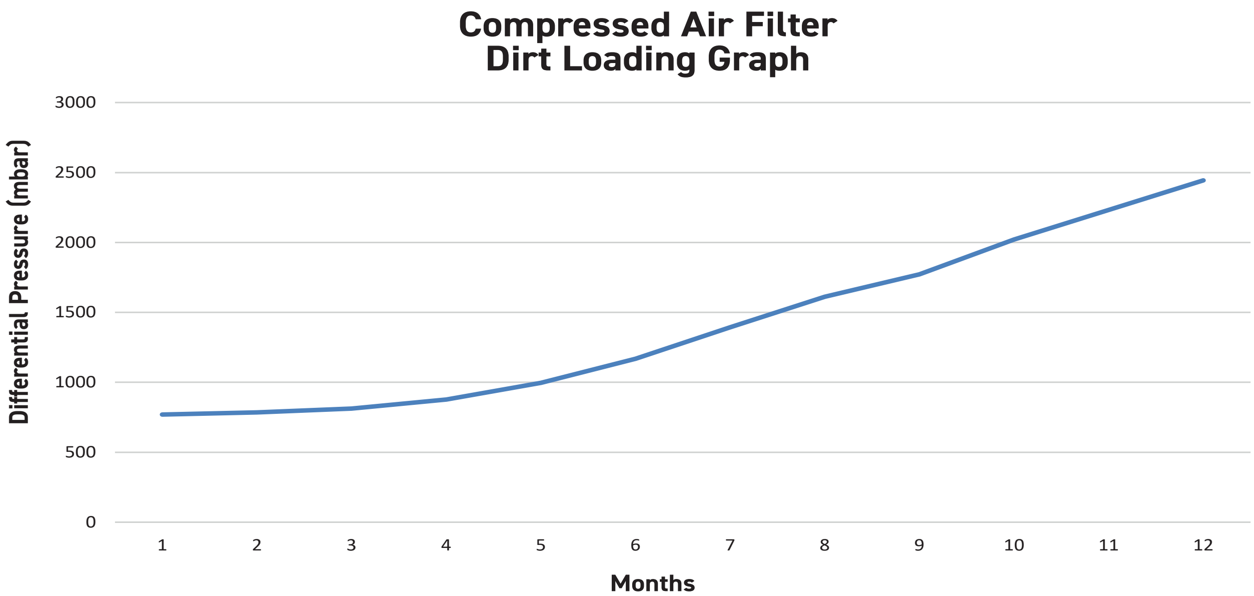
As coalescing & dry particulate filters operate, they capture atmospheric particulate, rust, pipescale and micro-organisms and as they do, the compressed air has a more tortuous path through the filter media, progressively increasing pressure losses the longer the filter is used.

Therefore, the differential pressure data shown in product literature data should never be used to estimate operational costs over 12 months.

When looking to calculate energy consumption costs for coalescing and dry particulate filters, the blockage characteristics of the filter should always be considered as this is an indication as to the filters dirt holding capacity.

New Filter Media

Blocked Filter Media



The graph above (highlighting cumulative differential pressure over time was produced using measured data from the dirt loading test of a coalescing filter commonly available on the market.

Although the manufacturers of this particular filter claims low dP and promises huge energy savings, the dirt loading tests show the filter to be inefficient, blocking quickly which will result in high operational costs.

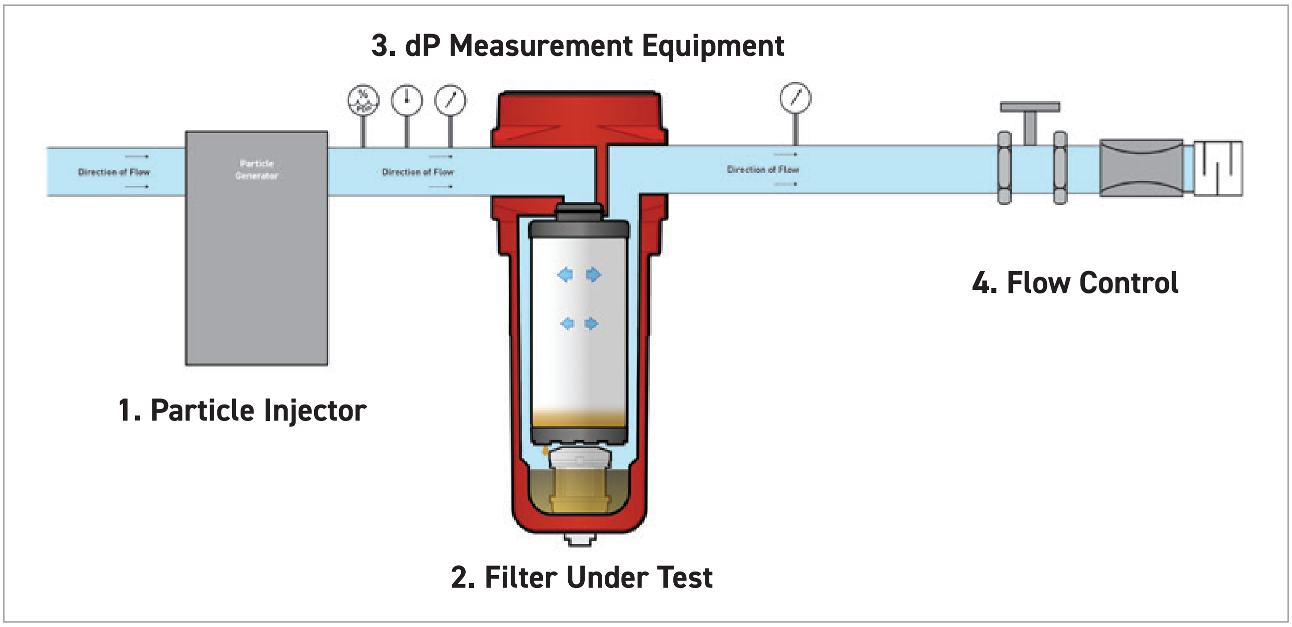
The True Cost Of Filter Operation

To calculate the true cost of operating a filter, you must consider the both initial pressure drop across the filter and the blockage characteristics of the filter element (how the filter element blocks with solid particulate from the compressed air and the storage & distribution system). Only when these factors have been considered, can the true cost of ownership be known.

Compressed Air Filter Dirt Load Testing

To determine the blockage characteristics of a compressed air filter, a specialist test rig is used. This test rig allows a measured amount of test particulate (equivalent to the filters monthly loading) to injected into the flow of compressed air upstream of a filter and the differential pressure across the complete filter recorded. This is carried out twelve times to simulate the filter blocking over a 12 month period.

The diagram below shows a dirt loading test rig.



The Dirt Loading Test rig consists of:

1. The Particle Injector
   - This device injects the sample of ISO 12103-1, A4 test dust into the compressed air stream
   - Ensures an even particle distribution in the air flow
2. The Filter Under Test
3. Differential Pressure Measuring Equipment
   - Used to measuring the difference between the inlet pressure and outlet pressure
   - dP measurement includes the fixed pressure loss of the housing & element interface and the incremental pressure losses as the filter blocks with the test particulate
4. Flow Control
   - Set at 100% of the test filters rated flow capacity

Dirt Load Test Procedure

1. Calculate challenge concentration equivalent to 12 months of filter usage based upon an inlet challenge concentration of 10 ug/m^3 of ISO 12103-1, A4 test dust
   - This is the total amount of particulate the filter could treat in 12 months of continuous operation
   - For example, if a filter has a maximum flow rate of 250m^3/hr and is tested with a challenge concentration of 10ug/m^3 of test particulate, then the filter will be challenged with a total of 250 m^3/hr x 10 ug/m^3 x 8736 hrs = 21.84 g of test particulate
2. Calculate challenge concentration equivalent to 1 month of filter usage
   - Total concentration above ÷ 12 = 1.82 g
3. Set up particle injector to deliver 1.82 g of test particulate.
4. Carry out ISO 12500-1 testing
   - This applies to coalescing filters only
   - Dirt load testing should be carried out directly after ISO 12500-1 testing whilst the element is still saturated with oil
5. Record element weight before testing begins
6. Flow the filter at 100% rated air flow
7. Record initial dP
   - Initial dry dP for dry particulate filters
   - Initial wet dP for Coalescing Filters
8. Inject test particulate into air flow
   - In this example, 1.83 g of test particulate.
9. Record differential pressure
10. Repeat steps 8 & 9 until the monthly challenge concentration has been injected into the air flow 12 times
    - To simulate 12 months of operation
    - Provides a cumulative dP figure
11. Record element weight after testing is completed
    - To confirm correct challenge has been applied
12. Graph data to show blockage characteristics of the filter on test

Turning Blockage Characteristics into Usable Data

Once the blockage characteristics of a filter is known, the differential pressure data can be converted into energy consumption, financial and environmental data, e.g. energy consumed in kW, operational cost and kg/CO_2 released during the generation of the electricity.

Additionally, with the purchase cost of the filter and element, the information can also be used to calculate the Total Cost of Ownership of a product.

Manufacturer	1 Yr Cost		5 Yr Cost		10 Yr Cost	
	Pound	Euro	Pound	Euro	Pound	Euro
Parker	£142	€166	£710	€827	£1421	€1656
Alt Manufacturer	£1088	€1267	£5440	€6340	£10881	€12680
Savings with Parker	£945	€1101	£4729	€5511	£9459	€11023

Example of a running cost comparison using dirt load testing data

Comparing Compressed Air Filters

To show the cost effectiveness of their OIL-X filter range, Parker GSFE division undertook a programme of comparative filter testing.

Using 1” ported models, filters were selected from several compressed air filter manufacturers whose product performance claims are similar to the OIL-X filter range.

The grades chosen for test were equivalent to Parker OIL-X Grade AO General Purpose Coalescing Filters & Grade AA High Efficiency Coalescing Filters.

The filters were first tested in accordance with ISO 12500-1 to determine if their oil carryover values were within the specification claimed in product literature.

The filters under test were then subjected to the dirt load testing highlighted previously. Oil Carryover data is included on the results graphs.

As the maximum flow rate of each 1” ported filter varies from manufacturer to manufacturer, the challenge concentration of particulate will also vary.

OIL-X filters were tested at their maximum rated flow and at the same flow and challenge concentration of the filter to which it is being compared. This is to give a like for like comparison of both filters.

Important notes:

- Filters with a 1” connection size were tested
- The flow rate of each 1” filter varies by manufacturer
- The inlet challenge concentration is per cubic metre of air
- Inlet challenge used = 10ug of ISO standard test dust per cubic metre of compressed air
- The total challenge concentration (gms) = inlet challenge/m^3 x flow rate (m^3/hr)
- Monthly loading = total challenge concentration (gms) ÷ 12
- Each filter was challenged with the monthly loading value 12 times
- dP was recorded after each challenge monthly challenge
- The higher the flow rate, the greater the quantity of oil aerosol and particulate presented to the filter

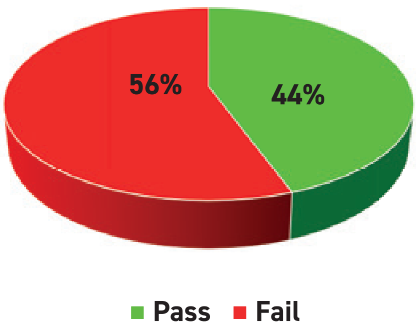
Comparative Testing (ISO 12500-1 Results)

Of 18 competitor filter models tested:

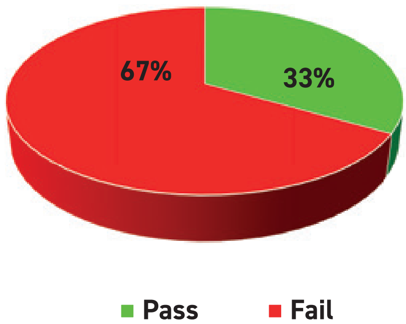
Only 44% of the general purpose grades achieved their literature claimed oil carryover values

And only 33% of the high efficiency grades achieved their literature claimed oil carryover values

General Purpose Grades Meeting Claimed Oil Carryover Specification When Tested in Accordance with ISO12500-1

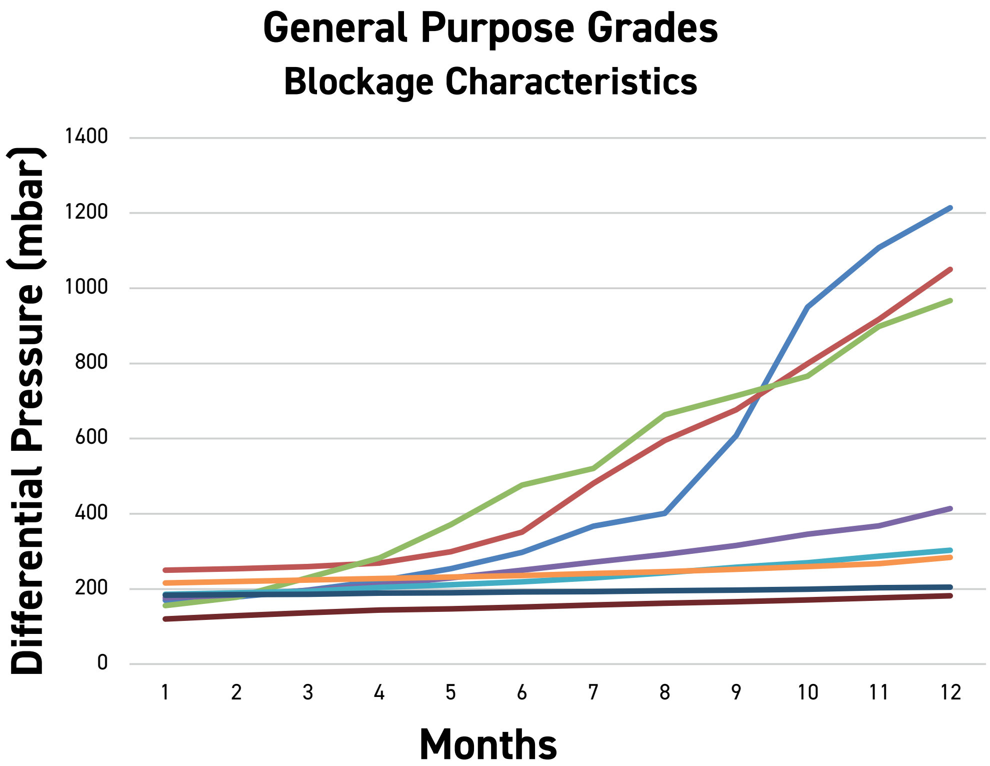


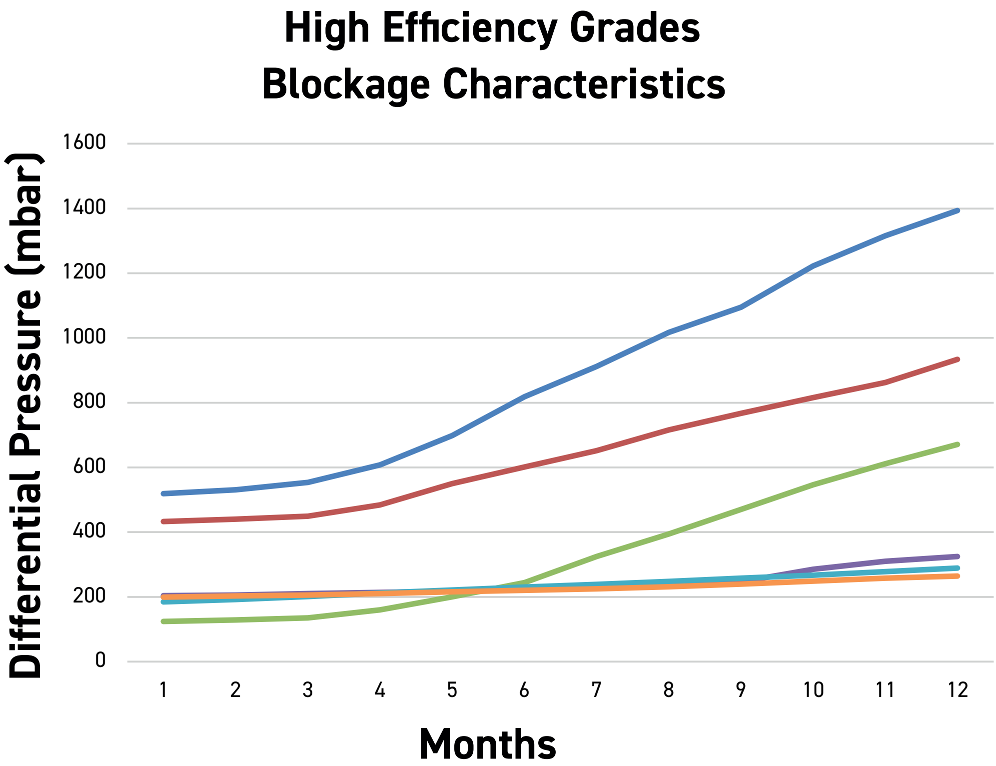
High Efficiency Grades Meeting Claimed Oil Carryover Specification When Tested in Accordance with ISO12500-1



Comparative Testing (Dirt Loading)

The graphs below show the blockage characteristics of the filters tested that achieve their claimed literature oil carryover values.



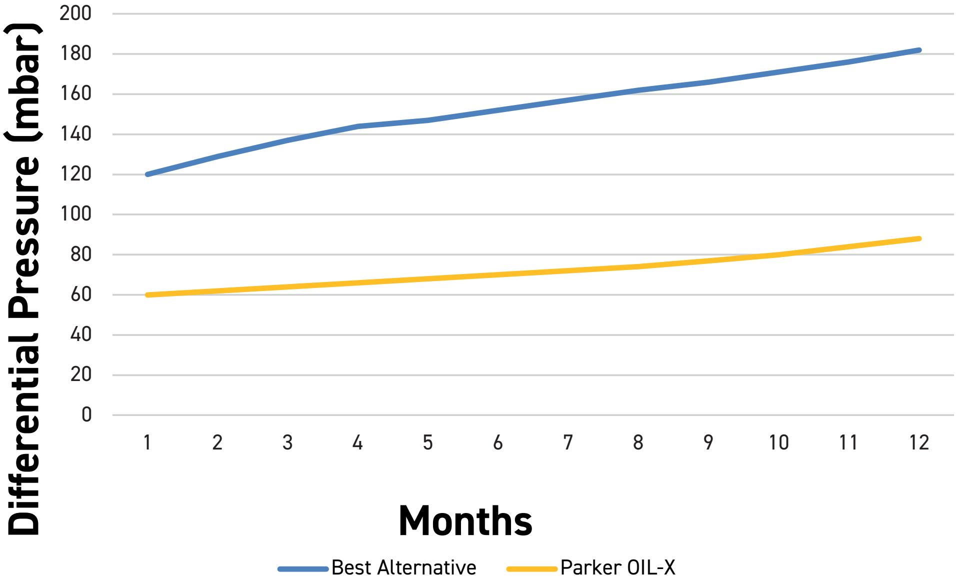


Parker OIL-X versus Best Alternative Coalescing Filter Tested

Comparing Parker OIL-X General Purpose & High Efficiency Grades against the best performing alternatives, highlights how OIL-X has been designed to have an extremely high dirt holding capacity and a differential pressure that starts low and stays low throughout its 12 month lifetime.

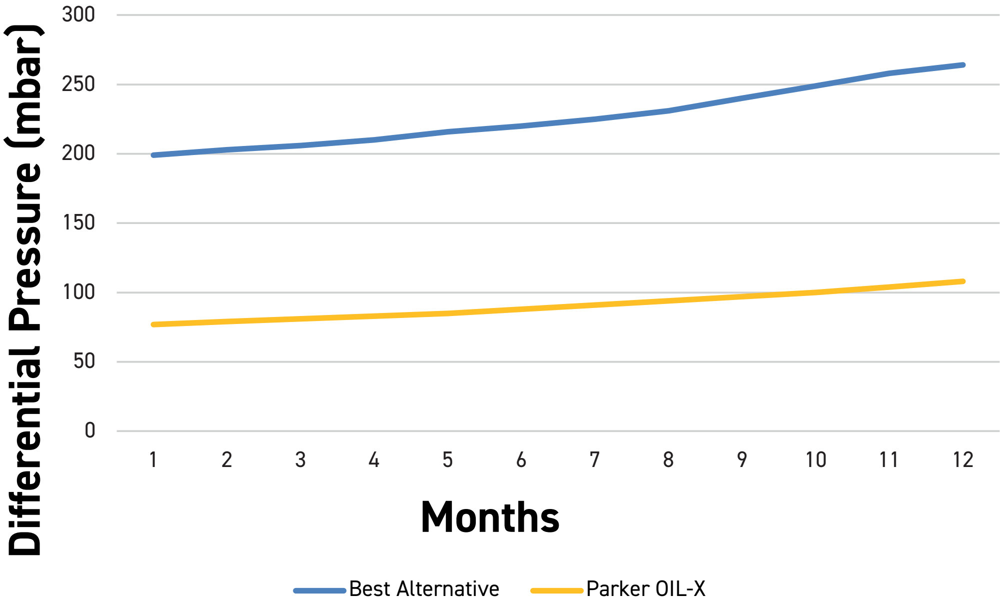
Parker v Best Alternative General Purpose Grades

Matched Flow & Challenge



Parker v Best Alternative High Efficiency Grades

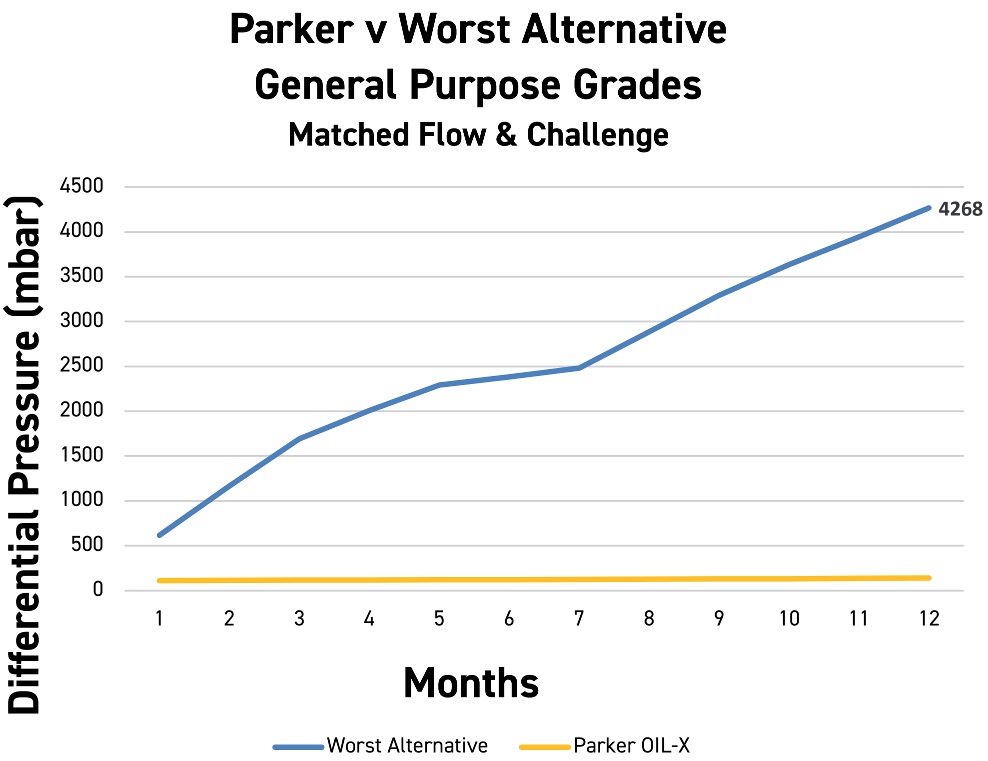
Matched Flow & Challenge

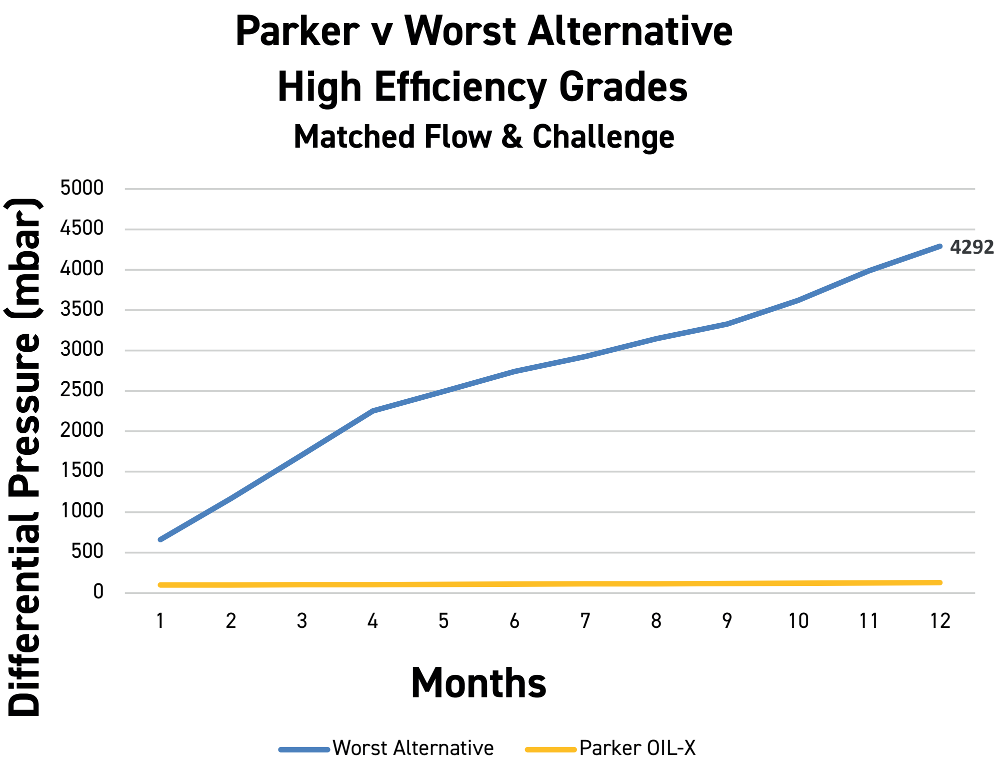


Note: The best alternative general purpose and high efficiency filters shown are from 2 separate manufacturers

Parker OIL-X versus Worst Alternative Coalescing Filter Tested

Comparing Parker OIL-X General Purpose & High Efficiency Grades against the worst performing alternatives, highlights how filters that look similar and claim similar performance in literature can have extremely different filtration performance, blockage characteristics and operational costs.





Note: The worst alternative general purpose and high efficiency filters shown are from the same manufacturer

Two Filters Are Better than One

To reduce pressure losses whilst ensuring the high levels of compressed air purity required by many industrial applications, a combination of filter grades will typically be used.

Coalescing filters should always be installed in pairs, however, it is not always understood why.

There is a common misconception when seeing two filters in an installation that one filter is an oil removal filter and the other is a particulate removal filter.

Unfortunately, this is not correct as both filters will actually be coalescing filters of differing filtration grades.

The pair of coalescing filters consisting of a General Purpose filter and High Efficiency filter.

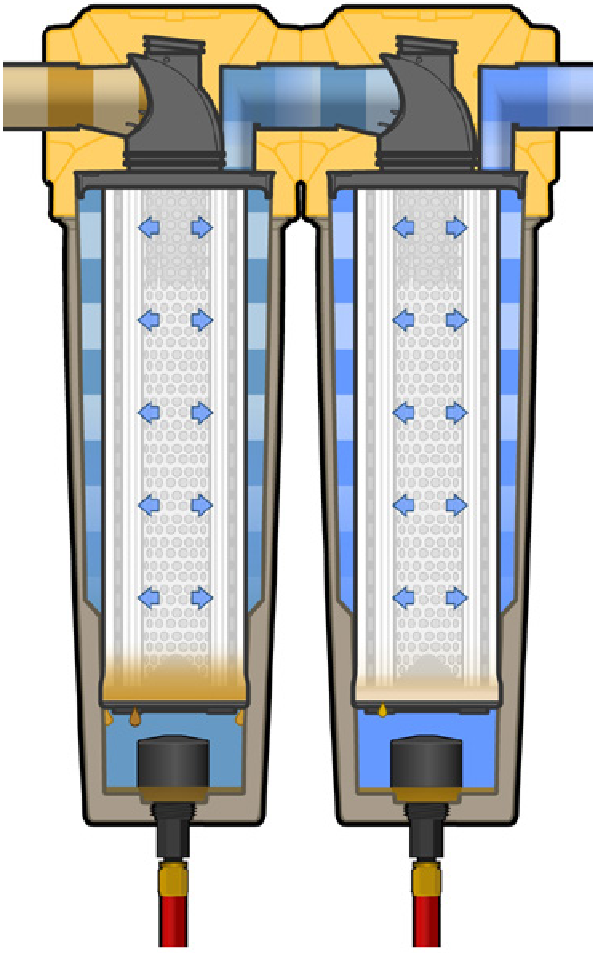
Both filters work in exactly the same way and both treat the same six contaminants commonly found in a compressed air system (these being oil aerosols / water aerosols / atmospheric particulates / rust / pipescale / micro-organisms).

The purpose of the first coalescing filter, the General Purpose grade is to pre-treat the air and protect the second filter, the High Efficiency grade filter from heavy contamination.

General-Purpose Coalescing Filters
A general-purpose coalescing filter will typically provide particle reduction down to 1 µm and an oil aerosol reduction around 0.5 mg/m^3 with an efficiency rating around 99.9%.

High Efficiency Coalescing Filters
When proceeded by a general-purpose coalescing filter, a high efficiency coalescing filter will typically provide particle reduction down to 0.01 µm and an oil aerosol reduction to around 0.01 mg/m^3 with an efficiency of 99.9999%.

Omitting a single filter can result in issues.
If a general purpose grade filter is used on its own, achieving ISO 8573-1 Class 1 for particulate and Class 1 or Class 2 for total oil will not be achievable (coalescing filters protect adsorption filters from aerosol contamination).



If a high efficiency grade filter is used on its own, this single filter has to treat all of the larger particulate and aerosols that would normally be reduced by the general purpose grade in addition to the smaller aerosols and particles that it is designed for, resulting in:

- Contaminant carryover
- Rapid blockage
- High pressure losses
- Frequent element changes

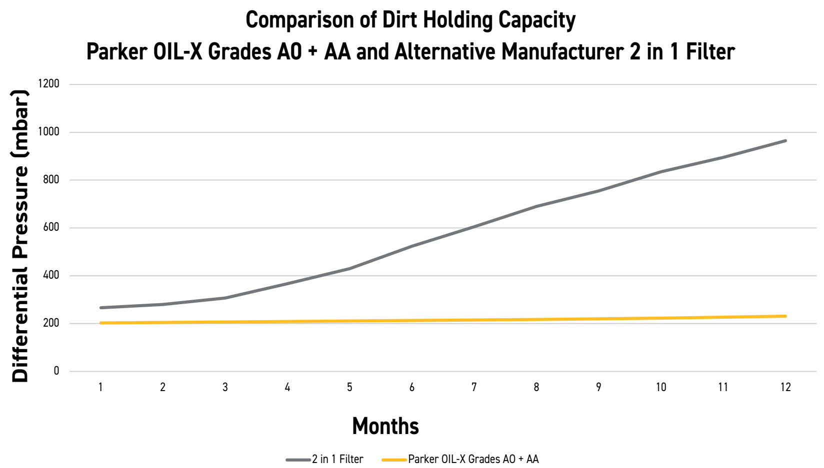
Best Practice is to always install coalescing filters in pairs

Two Coalescing Filters v's Single "2 in 1" Filter

In an attempt to reduce the pressure losses associated with compressed air filters, a number of manufacturers are now offering 2 in 1 filters which are claimed to reduce the pressure losses associated with the filter housing (and therefore energy consumption) whilst providing the same level of purification (i.e. particulate retention & oil carryover down to 0.01 micron / 0.01 mg/m^3 or lower). In theory, the thought process is a sound one.

Therefore, to show the true benefits of their new OIL-X filter range, a comparative test between a pair of Parker OIL-X coalescing filters (Grades AO + AA) and a single 2 in 1 filter was undertaken, following the ISO 12500-1 & Dirt Load Testing methodologies.

Results of the initial ISO12500-1 testing showed that whilst the OIL-X AO + AA combination achieved the claimed literature performance for oil carryover and initial wet differential pressure, the 2 in 1 filter oil carryover performance was 87% higher than literature claims and initial saturated differential pressure 5% higher.



Whilst the quoted performance dP of the two filters may look similar in literature, dirt load testing indicates otherwise as can be seen in the graph.

Testing confirmed that a pair of Parker OIL-X filters have a much higher dirt holding capacity than the 2 in 1 filter and will therefore have significantly lower operational costs.

Energy Savings

The dirt loading test data, can be directly translated into energy consumed by the compressor. The table shows the energy savings available by installing a pair of Parker OIL-X filters over a 2 in 1 filter.

Financial Implications

Using the information in the table, a user can calculate annual operational cost as well as the total cost of ownership of their filters.

For the filters used in this test, the initial purchase price for the two Parker OIL-X filters was only 26% higher than the 2 in 1 filter whilst a pair of Parker OIL-X filter elements were 42% lower than a single element for the 2 in 1. As the 2 in 1 filter has a lower operating lifetime than OIL-X, it may require 2 element changes per year in which case the pair of OIL-X elements are 183% lower cost than a pair of 2 in 1 elements.

Based Upon a 37 kW Compressor	Total Energy Consumed in 1 Year of Continuous Operation
2 in 1 Filter	12,371 kW
Parker OIL-X (Grades AO+AA)	4,704 kW
Saving with Parker OIL-X	7,670 kW
Saving with Parker OIL-X (%)	62%

What seems like a low cost alternative may turn out to be a costly investment

Parker OIL-X
#1 in filtration

At Parker we continually develop our filtration ranges to ensure that every compressed air filter we deliver offers the right balance between filtration performance and energy consumption, resulting in a reliable compressed air system with low total cost of ownership.

Air Quality

- **Coalescing Filter Performance tested in accordance with ISO12500-1:2004, ISO 8573-2:2018 & ISO 8573-4:2019**
- **Filtration performance independently verified by Lloyds Register**
- **Only filter range to offer a one year air quality guarantee**

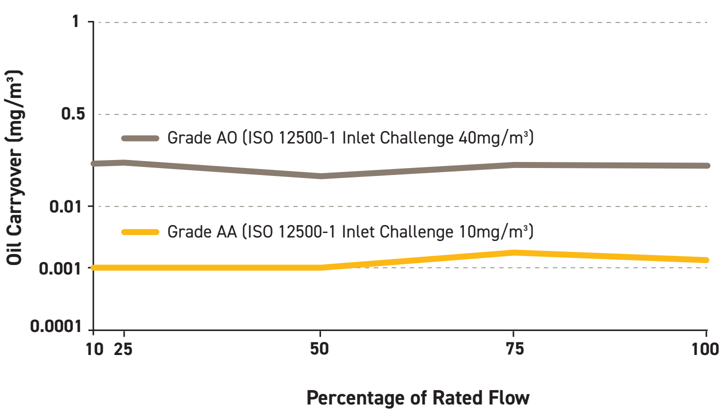
Parker OIL-X - Filtration Performance at all flow conditions

The ISO 12500-1 standard was designed to tests a coalescing filter at its worst-case parameters of 100% maximum rated flow, however it does not include a requirement to test a filter at partial flow. As coalescing filter construction varies from manufacturer to manufacturer, performance at partial flow can vary and whilst a filter may perform well at 100% of rated flow, it may not do so at lower flow rates.

Due to the unique OIL-X filter element construction, for each port size, the OIL-X filter range has some of the highest flow rates available today. However, filters are seldom operated at 100% of rated flow. Many filters are often selected to match pipe size of the installation. Additionally, many compressed air systems are installing variable speed compressors that adjust air flow to better match energy consumption to air demand.

The Parker OIL-X filtration range has been designed to maintain filtration performance with variable inlet flow rates such as those found when variable speed compressors are installed. As can be seen in the graph, OIL-X filtration efficiency remains constant at partial flow conditions from 10% to 100% of the filters rated capacity.

OIL-X Grade AO & AA Oil Carryover versus Flow

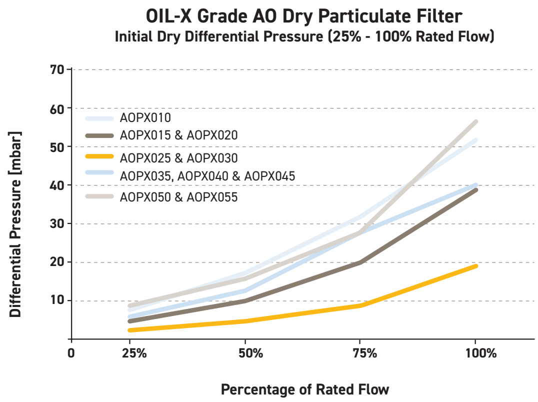


Energy Efficiency

- **First industrial filter range to provide Differential Pressure (dP) data for individual models**
- **First industrial filter range to provide dP data at variable flow conditions (25% / 50% / 75% 100% of rated flow)**
- **First industrial filter range to provide dP curves for each filter model**

Parker understands that filters are not always operated at 100% of rated flow, therefore Parker OIL-X is the first industrial filter range to show the initial dry and initial saturated differential pressure data for each individual filter (not just the filter range) and at 25%, 50%, 75% & 100% of the filters maximum flow rate).

Model	Initial Saturated Differential Pressure			
	100% Flow	75% Flow	50% Flow	25% Flow
	mbar	mbar	mbar	mbar
AOPX010A	61	40	20	9
AOPX015B	60	38	23	12
AOPX015C	27	15	10	5

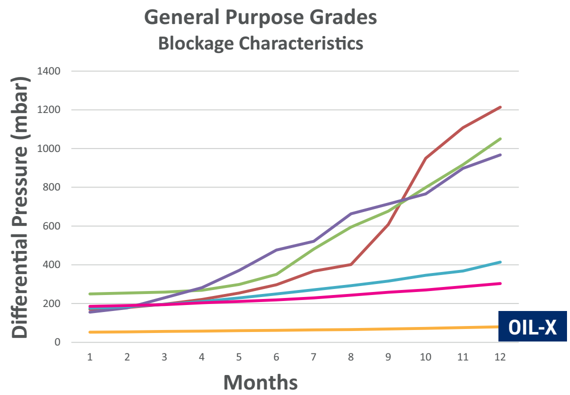


Low Lifetime Costs

Finding the initial dry and initial saturated differential pressure of a filter is just the start when looking at filter energy consumption. These figures are important, but only relate to a clean, out of the box filter and are an indication of a filter's energy consumption at the beginning of its life.

Today, many different brands of compressed air filter are available. Although visually similar, and with performance that on paper may appear identical, when put into operation, a very different story is often told.

Compressed air filters are often bought with a compressor; as part of a package deal and therefore selected based upon purchase cost, with little or no regard for the delivered air quality or total cost of ownership.



Parker OIL-X - Differential Pressure Starts Low & Stays Low

A filter with a low purchase price may not always turn out to be the most cost effective solution.

Environmentally Friendly

REDUCED CO_2

Many countries worldwide are looking closely at their manufacturing industries in an effort to reduce the amount of harmful greenhouse gases released into the atmosphere.

The use of electricity has a direct impact on the generation and release of CO_2.

By reducing energy consumption, efficient filtration helps to reduce the carbon footprint of a manufacturing facility and protects the environment.

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